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ARTICLES WITH RADIATION CURED ADHESIVE AS ALTERNATIVE TO HEAT SEALS

25 Field Of The Invention

The present invention relates to a container or container component, e.g. a thermoplastic container or container component, such as a bag (e.g. for food packaging), including containers made from a crosslinked film; a thermoformed container; a film/foam composite; or an inflatable packaging cushion; in each of which at least two plies of film, or at least one ply of film and at least one ply of foam, are joined together by a radiation curable adhesive.

30 Background Of The Invention

In many packaging applications, for food and non-food markets, films and film/foam combinations, such as thermoplastic films and film/foam combinations, are widely used in making the packaging or components thereof.

35 For example, flexible film bags have been manufactured and sold for the packaging of a wide variety of products, including fresh red meat, smoked and processed meat, etc. Examples are shown in U.S. Patent No. 6,282,869 (Bullock et al.) incorporated herein

by reference in its entirety. The film for these bags sometimes comprises a coextruded, totally irradiated and therefore crosslinked structure, and sometimes an extrusion coated material with an irradiated, crosslinked substrate and an unirradiated, uncrosslinked extrusion coating.

- 5 Thermoformed containers likewise are used in packaging many food and non-food products, and typically include a thermoformed substrate and a lidding film. Examples are shown in U.S. Patent No. 4,729,476 (Lulham et al.) incorporated herein by reference in its entirety.

10 Film/foam composites are formed e.g. when a barrier liner is adhered to a foamed or solid tray, such as a polystyrene, polycarbonate, or polyolefin tray. Examples are shown in U.S. Patent No. 5,952,076 (Foster et al.) incorporated herein by reference in its entirety.

- 15 Packagers are increasingly using air-inflated cushions formed from relatively thin films of thermoplastic to protect their packaged goods within boxes, sleeves, or cases during shipping and storage. See U.S. Patent Nos. 5,803,263 (Pozzo), and 6,276,532 and 6,569,283 (Sperry et al.), all incorporated herein by reference in their entirety. For example, an inflatable packaging cushion system that can protect a wide variety of packaged goods is sold by Sealed Air Corporation under the VISTAFLEX™ trademark. The VISTAFLEX™ inflatable packaging cushion includes an inflation inlet designed for use with an inflation/sealing machine provided by Sealed Air Corporation under the BT-1™ trademark.
- 20 The BT-1 inflator/sealer controls both the inflation of the cushion with compressed air and sealing of the inflated cushion with an impulse heat sealer. To inflate and seal the VISTAFLEX™ cushion, a user inserts an inflation tube into an inflation inlet of the cushion. The inflator/sealer inflates the cushion by opening a valve to allow compressed air to pass through the inflation tube into the interior of the cushion chamber until the cushion chamber has been inflated to the desired pressure. At that point, a heat seal bar compresses the top and bottom sheets of the inlet to prevent the inflated cushion from deflating. An inflatable packaging cushion is a useful form of protective packaging for applications where the cushioning effect of the material offers protection of a fragile product from physical shock and damage during shipping of the product. An object to be packaged is,
- 25 after inflating the inflatable packaging cushion, intimately wedged between the internal faces of the cushion which, by its deformability, adapts to the shape and/or size of the ob-
- 30

ject. Thus, such a packaging item can be used for packaging articles of various dimensions and shapes by suitably wedging them each time.

Common to these packaging formats is a heat-sealing process, or alternative adhesion techniques such as radio frequency sealing, gluing, etc. to join films or film plies together, or to join film or film plies to one or more foam plies. In the case of flexible bags, a "factory seal" is typically made, referring to any and all seals necessary to convert a film tubing or flat film into a bag having an open end. Such seals are usually made at a bag-making factory, rather than at location at which products are being packaged.

Heat sealing of certain polymeric materials can be difficult and relatively slow. In the case of dissimilar materials, heat sensitive materials (such as some foams), or crosslinked materials, heat sealing can sometimes become so technically difficult or impossible as to be commercially unfeasible. Heat can degrade some foam materials.

In the case of heat shrinkable films, heat sealing frequently results in some degree of puckering of the film material in the area of the heat seal, triggered of course by the application of heat to the seal area of the package. This phenomenon can degrade the aesthetics of the package, and in extreme cases make the package unusable from a commercial viewpoint.

Also, where intricate sealing patterns, geometries, or profiles are desired, or else dictated by the shape of the package, e.g. in the case of an inflatable packaging cushion, it can be difficult and expensive to design heat seal tooling that will adequately and reliably create the patterns.

In accordance with the present invention, radiation curable adhesives can be used to bond together films or film and foam, in the production of a containers or container component, e.g. a thermoplastic containers or container component, such as a bag (e.g. for food packaging), including a container made from a crosslinked film; a thermoformed container; a film/foam composite; or an inflatable cushioning material; in each of which at least two plies of film, or at least one ply of film and at least one ply of foam, are to be joined together.

#### Summary of the Invention

In a first aspect of the invention, a bag comprises a first panel; a second panel; first and second layflat side edges; a bottom edge; and a bag mouth; wherein at least one of

the first and second layflat side edges, and the bottom edge, comprises a radiation cured adhesive layer bonding the first and second panels together.

In a second aspect of the invention, a thermoformed container comprises a forming web, the forming web comprising a polymeric material; a substantially non-forming 5 web comprising a polymeric material; and a radiation cured adhesive layer disposed between and bonding at least portions of the forming web and the substantially non-forming web.

In a third aspect of the invention, a film/foam composite comprises a thermoplastic film comprising a polymeric material; a polymeric foam sheet; and a radiation cured adhesive layer disposed between and bonding at least portions of the thermoplastic film and 10 the polymeric foam sheet.

In a fourth aspect of the invention, an inflatable packaging cushion comprises a plurality of flexible plastic sheets bonded together in the region of their edges, wherein a radiation cured adhesive layer bonds at least a portion of the flexible plastic sheets together. 15

#### Brief Description of the Drawings

A detailed description of embodiments of the invention follows, with reference to the attached drawings, wherein:

- FIG. 1 is a schematic of an end-seal bag in lay-flat view;
- 20 FIG. 2 is a cross-sectional view through section 2--2 of FIG. 1;
- FIG. 3 is a schematic of a side-seal bag in lay-flat view;
- FIG. 4 is a cross-sectional view through section 4--4 of FIG. 3;
- FIG. 5 is a fragmentary cross-sectional view through section 5--5 of FIG. 1;
- FIG. 6 is a fragmentary cross-sectional view of an side seal of FIG. 4;
- 25 FIG. 7 is a schematic of a process and apparatus for making a film useful in the invention;
- FIG. 8 is a schematic cross-sectional view of a film useful with the invention;
- FIG. 9 is a schematic cross-sectional view of a film useful with the invention; FIG.
- 10 is a plan view of a thermoformed container of the invention;
- 30 FIG. 11 is a side view of the container of FIG. 10;
- FIG. 12 is a cross-sectional view taken along line XII--XII of FIG. 10;
- FIG. 13 is an enlarged cross-sectional view of the container of FIG. 12;

FIG. 14 is a schematic cross-sectional view of a film/foam composite of the invention;

FIG. 15 is a schematic of a process and apparatus for making a film/foam composite of the invention;

5 FIG. 16 is a plan view of a first embodiment of an inflatable cushion in accordance with the invention, in the deflated state;

FIG. 17 is a plan view of the inflatable cushion of FIG. 16, in the inflated state;

10 FIG. 18 is a perspective view of the inflatable cushion of FIG. 16, in the inflated state;

FIG. 19 is a plan view of a first alternative embodiment of the inflatable cushion of FIG. 16, in the deflated state;

FIG. 20 is a plan view of a second alternative embodiment of the inflatable cushion of FIG. 16, in the deflated state;

15 FIG. 21 is a plan view of an inflatable cushion according to the invention, in the deflated state, comprising a self-sealing valve in a corner;

FIG. 22 is a sectional view along line A--A' of the self-sealing valve in a corner of the inflatable cushion of FIG. 21;

20 FIG. 23 is a detailed view of the self-sealing value in a corner and of two tabs for guiding the inflatable cushion of FIG. 21;

FIG. 24 is a sectional view along line B--B' of the valve and of the two tabs of FIG. 23;

FIG. 25 is a detailed view of an alternative embodiment of the self-sealing valve of FIG. 21;

25 FIG. 26 is a schematic view of an apparatus and process for making a bag of the invention;

FIG. 27 is a plan view of a web printed with a patterned seal design;

FIG. 28 is a plan view of the printed web of FIG. 27 after lamination to a second web; and

30 FIG. 29 is a plan view of a waste web resulting from the process of the invention.

Definitions

As used herein, the term:

"abuse layer" and the like refers to an outer film layer and/or an inner film layer, so long as the film layer serves to resist abrasion, puncture, and other potential causes of reduction of package integrity, as well as potential causes of reduction of package appearance quality. Abuse layers can comprise any polymer, so long as the polymer contributes to achieving an integrity goal and/or an appearance goal; examples include ethylene/alpha-olefin copolymer having a density of from about 0.85 to 0.95, propylene/ethylene copolymer, polyamide, ethylene/vinyl acetate copolymer, ethylene/methyl acrylate copolymer, and ethylene/butyl acrylate copolymer, etc..

"barrier" as applied to films and/or film layers, refers to the ability of a film or film layer to serve as a barrier to one or more gases. Barrier materials have an oxygen permeability, of the barrier material, less than  $500 \text{ cm}^3 \text{ O}_2 / \text{m}^2 \cdot \text{day} \cdot \text{atmosphere}$  (tested at 1 mil thick and at  $25^\circ\text{C}$  according to ASTM D3985), such as less than 100, less than 50 and less than  $25 \text{ cm}^3 \text{ O}_2 / \text{m}^2 \cdot \text{day} \cdot \text{atmosphere}$  such as less than 10, less than 5, and less than  $1 \text{ cm}^3 \text{ O}_2 / \text{m}^2 \cdot \text{day} \cdot \text{atmosphere}$ . Examples of polymeric materials with low oxygen transmission rates are ethylene/vinyl alcohol copolymer (EVOH), polyvinylidene dichloride (PVDC), vinylidene chloride/ methyl acrylate copolymer, polyamide, polyester, metal foil,  $\text{SiO}_x$  compounds, and metallized foils such as a sputter coating or other application of a metal layer to a polymeric substrate such as high density polyethylene (HDPE), ethylene/vinyl alcohol copolymer (EVOH), polypropylene (PP), polyethylene terephthalate (PET),polyethylene naphthalate (PEN), or polyamide (PA). Even a sufficiently thick layer of a polyolefin such as LLDPE, or PVC (polyvinyl chloride) can in some instances provide a sufficiently low oxygen transmission rate for the overall film for its intended function. The exact oxygen permeability optimally required for a given application can readily be determined through experimentation by one skilled in the art.

"bonding layer" and the like refers to an outermost film layer (or the single layer of a monolayer film) involved in the bonding of the film to itself, to another film layer of the same or another film, and/or another article or container component which is not a film. can comprise any thermoplastic polymer;

"bulk layer" refers to any layer of a film which is present for the purpose of increasing the abuse-resistance, toughness, modulus, etc., of a multilayer film. Bulk layers can comprise polymers which are inexpensive relative to other polymers in the film, and/or which provide some specific purpose unrelated to abuse-resistance,

modulus, etc. Examples include polyolefin; ethylene/alpha-olefin copolymer, low density polyethylene, and linear low density polyethylene.

"ethylene/alpha-olefin copolymer" (EAO) refers to copolymers of ethylene with one or more comonomers selected from C<sub>3</sub> to C<sub>10</sub> alpha-olefins such as propene, butene-

- 5 1,hexene-1, octene-1, etc. in which the molecules of the copolymers comprise long polymer chains with relatively few side chain branches arising from the alpha-olefin which was reacted with ethylene. This molecular structure is to be contrasted with conventional high pressure low or medium density polyethylenes which are highly branched with respect to EAOs and which high pressure polyethylenes contain both long chain and short  
10 chain branches. EAO includes such heterogeneous materials as linear medium density polyethylene (LMDPE), linear low density polyethylene (LLDPE), and very low and ultra low density polyethylene (VLDPE and ULDPE), such as DOWLEX™ or ATTANE™ resins supplied by Dow, and ESCORENE™ or EXCEED™ resins supplied by Exxon; as well as linear homogeneous ethylene/alpha olefin copolymers (HEAO) such as TAFMER™ resins  
15 supplied by Mitsui Petrochemical Corporation, EXACT™ resins supplied by Exxon, or long chain branched (HEAO) AFFINITY™ resins supplied by the Dow Chemical Company, or ENGAGE™ resins supplied by DuPont Dow Elastomers.

"ethylene homopolymer or copolymer" herein refers to ethylene homopolymer such as low density polyethylene; ethylene/alpha olefin copolymer such as those defined  
20 herein; ethylene/vinyl acetate copolymer; ethylene/alkyl acrylate copolymer; ethylene/(meth)acrylic acid copolymer; or ionomer resin.

"film" and the like refers to plastic web, regardless of whether it is film or sheet. Films used in the present invention have a thickness of 0.5 to 40 mils.

- 25 "oriented" refers to a polymer-containing material which has been stretched at an elevated temperature (the orientation temperature), followed by being "set" in the stretched configuration by cooling the material while substantially retaining the stretched dimensions. Upon subsequently heating unrestrained, unannealed, oriented polymer-containing material to its orientation temperature, heat shrinkage is produced almost to the original unstretched, i.e., pre-oriented dimensions. More particularly, the term "oriented",  
30 as used herein, refers to oriented films, wherein the orientation can be produced in one or more of a variety of manners.

"polymer" refers to the product of a polymerization reaction, and is inclusive of homopolymers, copolymers, terpolymers, etc.

"polyolefin" refers to any polymerized olefin, which can be linear, branched, cyclic, aliphatic, aromatic, substituted, or unsubstituted. Specific examples include polyethylene

- 5 homopolymer, polypropylene homopolymer, polybutene, ethylene/alpha-olefin copolymer, propylene/alpha-olefin copolymer, butene/alpha-olefin copolymer, ethylene/vinyl acetate copolymer, ethylene/ethyl acrylate copolymer, ethylene/butyl acrylate copolymer, ethylene/methyl acrylate copolymer, ethylene/acrylic acid copolymer, ethylene/methacrylic acid copolymer, modified polyolefin resin, ionomer
- 10 resin, polymethylpentene, etc.

"tie layer" refers to any internal layer having the primary purpose of adhering two layers to one another. Tie layers can comprise any polymer having a polar group grafted thereon, so that the polymer is capable of covalent bonding to polar polymers such as polyamide and ethylene/vinyl alcohol copolymer. Tie layers can comprise polyolefin,

- 15 modified polyolefin, ethylene/vinyl acetate copolymer, modified ethylene/vinyl acetate copolymer, and homogeneous ethylene/alpha-olefin copolymer; anhydride modified grafted linear low density polyethylene, anhydride grafted low density polyethylene, homogeneous ethylene/alpha-olefin copolymer, and anhydride grafted ethylene/vinyl acetate copolymer.

All compositional percentages used herein are presented on a "by weight" basis,  
20 unless designated otherwise.

#### Detailed Description Of The Invention

##### Bags: Article

Film in the form of seamless tubing can be converted into end-seal bags. FIG. 1 is a lay-flat view of a end-seal bag 10 of the present invention. End-seal bag 10 is made  
25 from seamless tubular film 12, and has a bag mouth 14, first and second lay-flat side edges 16 and 18, bottom edge 20, and end-seal 22. FIG. 2 illustrates a cross-sectional view of end-seal bag 10 taken through section 2--2 of FIG. 1.

In the end-seal bag, therefore, the side edges of the bag are actually formed by lay flat folds in the seamless tubing. The bottom edge of the bag is a cut in the tubing that is  
30 closed by the application of a radiation curable adhesive to the internal surface of the bottom portion of either or both of first and second panels (24 and 26) of the bag. The radiation curable adhesive is thus disposed between the bottom portions of the front and rear

panels (24 and 26) of the bag. The radiation curable adhesive is cured as disclosed herein to bond together these portions. Figure 5 shows a fragmentary enlarged cross sectional view of the end seal 22. A radiation cured adhesive layer or region 42 bonds together the internal surfaces of first panel 24 and second panel 26. Although shown in Figure 5 as a continuous layer, the radiation cured adhesive layer can alternatively be discontinuous in nature, disposed in selected regions but not continuously across the width of the bottom seal 22 of the bag 10. The radiation cured adhesive layer can also vary in its vertical extent along the seal (vertical as viewed in the plan view of Figure 1). Finally, the thickness or depth of the radiation cured adhesive layer, although shown in Figure 5 as of uniform thickness, can vary in thickness either within one applied coat of adhesive, or by means of multiple coats of adhesive in selected regions of the overall seal area.

Alternatively, film in the form of seamless tubing can be converted into side-seal bags. FIG. 3 is a lay-flat view of side-seal bag 30 of the present invention. Side-seal bag 30 is made from dual-seamed tubular film 32, and has open top 34, first and second side seals 36 and 38, and bottom edge 40. FIG. 4 is a cross-sectional view of side-seal bag 30, taken through section 4--4 of FIG. 3.

In the side-seal bag, therefore, the bottom edge of the bag is actually formed by a lay flat fold in the seamless tubing. The side edges of the bag are cuts in the tubing that are closed by the application of a radiation curable adhesive to the internal surface of the side edge portions of either or both of front and rear panels (44 and 46) of the bag. The radiation curable adhesive is thus disposed between the side edge portions of the front and rear panels (44 and 46) of the bag. The radiation curable adhesive is cured as disclosed herein to bond together these portions. Figure 6 shows a fragmentary enlarged cross sectional view of the side seal 36. A radiation cured adhesive layer or region 48 bonds together the internal surfaces of first panel 44 and second panel 46. Although shown in Figure 6 as a continuous layer, the radiation cured adhesive layer can alternatively be discontinuous in nature, disposed in selected regions but not continuously across the length of the side seal 36 of the bag 30. The radiation cured adhesive layer can also vary in its lateral extent along the seal (lateral as viewed in the plan view of Figure 3). Finally, the thickness or depth of the radiation cured adhesive layer, although shown in Figure 6 as of substantially uniform thickness, can vary in thickness either within one applied

coat of adhesive, or by means of multiple coats of adhesive in selected regions of the overall seal area.

The teaching herein relating to side seal 36, and alternative embodiments thereof, apply mutatis mutandis to side seal 38.

5        Bags: Process

The bags of the invention as described herein are made from thermoplastic film. Film for the production of the bags as described herein can be produced by any suitable method, e.g. in accordance with a process schematically illustrated in FIG. 7. In the process illustrated in FIG. 7, solid polymer beads (not illustrated) are fed to one or a plurality of 10 extruders 29 (for simplicity, only one extruder is illustrated). Inside extruders 29, the polymer beads are forwarded, melted, and degassed, following which the resulting bubble-free melt is forwarded into die head 31, and extruded through an annular die, resulting in tubing 33 which can be of any suitable thickness, e.g. 5 to 25 mils thick. After cooling or quenching by water spray from cooling ring 35, tubing 33 is collapsed by pinch rolls 37, 15 and is thereafter fed through irradiation vault 39 surrounded by shielding 41, where tubing 33 is irradiated with high energy electrons (i.e., ionizing radiation) from iron core transformer accelerator 43. Tubing 33 is guided through irradiation vault 39 on rolls 45. Tubing 33 is irradiated to a level of e.g. from 10 to 70 kiloGrays. After irradiation, irradiated tubing 47 is directed through pinch rolls 49, following which irradiated tubing 47 is slightly inflated, 20 resulting in trapped bubble 50. However, at trapped bubble 50, the tubing is not significantly drawn longitudinally, as the surface speed of nip rolls 52 are about the same speed as nip rolls 49. Furthermore, irradiated tubing 47 is inflated only enough to provide a substantially circular tubing without significant transverse orientation, i.e., without stretching. Slightly inflated, irradiated tubing 50 is passed through vacuum chamber 54, and thereaf- 25 ter forwarded through coating die 56. Second tubular film 58 is melt extruded from coating die 56 and coated onto slightly inflated, irradiated tube 50, to form two-ply tubular film 60. Second tubular film 58 can comprise an oxygen -barrier layer, which does not pass through the ionizing radiation. Further details of the above-described coating step are generally as set forth in U.S. Pat. No. 4,278,738, to BRAX et. al., which is hereby incorpo- 30 rated by reference thereto, in its entirety.

After irradiation and coating, two-ply tubing film 60 is wound up onto windup roll 62. Thereafter, windup roll 62 is removed and installed as unwind roll 64, on a second

stage in the process of making the tubing film as ultimately desired. Two-ply tubular film 60, from unwind roll 64, is unwound and passed over guide roll 66, after which two-ply tubular film 60 passes into hot water bath tank 68 containing hot water 70. The now collapsed, irradiated, coated tubular film 60 is submersed in hot water 70 (having a temperature of e.g. 185.degree. F.) for a retention time of at least about 30 seconds, i.e., for a time period in order to bring the film up to the desired temperature for biaxial orientation.

Thereafter, irradiated tubular film 60 is directed through nip rolls 72, and bubble 74 is blown, thereby transversely stretching tubular film 60. Furthermore, while being blown, i.e., transversely stretched, nip rolls 76 draw tubular film 60 in the longitudinal direction, as nip rolls 76 have a surface speed higher than the surface speed of nip rolls 72. As a result of the transverse stretching and longitudinal drawing, irradiated, coated biaxially-oriented blown tubing film 78 is produced, this blown tubing having been both transversely stretched in a ratio of e.g. from 1:1.5 to 1:6, and drawn longitudinally in a ratio of e.g. from 1:1.5 to 1:6. Alternative ratios are from 1:2 to 1:4 (transverse direction) and from 1:2 to 1:4 (longitudinal direction).

While bubble 74 is maintained between pinch rolls 72 and 76, blown tubing 78 is collapsed by rolls 80, and thereafter conveyed through pinch rolls 76 and across guide roll 82, and then rolled onto wind-up roll 84. Roll 86 assures a good wind-up.

Those skilled in the art will understand that many variations in the above film making process can offer alternative processing. For example, a full coextrusion process can be used instead of an extrusion coating process, particularly where polymeric materials compatible with the irradiation process are used, or where the film is not irradiated. Flat cast extrusion can be used, followed by standard tenterframing techniques to accomplish orientation of the film. Bags can then be made by back seaming and end sealing methods well known in the art, but with the use of radiation curable adhesives in place of heat sealing. Monoaxial orientation can be employed, or the film can remain unoriented, that is, not stretch oriented as described above. Irradiation can alternatively be employed after the film has been fully coextruded.

It should also be noted that radiation curable adhesives can be used to produce one or more seals of a bag with multiple seals, and heat sealing or another alternative sealing mechanism (adhesive, glue, radio frequency sealing, ultrasonic sealing, etc.) can be used to produce one or more of the remaining seals of the bag.

End seal and side seal bags can then be made from the biaxially-oriented blown tubing film.

- Referring to Figures 26 through 29, two polymeric film webs 122 and 124 are fed, from feed rolls 126 and 128 respectively into individual haul off nip rolls 130 and 132 respectively whereby the film webs are unwound from rolls 126 and 128. Web 126 is advanced through a printing process 134, whereby the predetermined pattern 135 of the radiation curable adhesive and the seal or weld that will result therefrom after curing) is printed on a surface of web 126 with a radiation curable adhesive. Figure 27 is a view of web 126 after printing. The two webs 122 and 124 are then brought together at the junction of rolls 136 and 138 (see Figure 28). Just prior to that joining, the radiation curable adhesive is exposed to a dose of ultraviolet light, at station 140, effective to cure the radiation curable adhesive and thereby bond the two webs together at points on the respective webs contacted by the pattern 135. Immediately after the exposure, the two webs are conveyed by a set of nip rollers 142a and 142b.
- The joined webs are then advanced, e.g. by conveyor, to a station 146 where the predetermined pattern 135 of each bag is cut. This can be accomplished by means of an intermittent operation using a flat steel rule die, or a rotary steel rule die 148 against a rotary steel anvil 150. The waste web 152 is then conveyed away (see Figure 29), while the individual bags are then laid in imbricated (shingled) fashion on conveyor 156. Waste web 152 in this embodiment will exhibit patterned holes 153 reflecting the conformation of the bags cut from the web.

In an alternative embodiment, a tubular web can be single edge slit and unfolded to provide one of the webs described hereinabove with respect to the process of Figure 26; or the tubular web can be edge slit and ply separated into two separate flat webs that can then function as each of the webs disclosed in connection with Figure 26.

Films useful in connection with the invention can be monolayer films or multilayer films. If multilayer, the film can have any suitable number of layers, such as a total of from 2 to 20 layers.

In general, the film can have any total thickness desired, and each layer can have any thickness desired, so long as the film provides the desired properties for the particular packaging operation in which the film is used, e.g. abuse-resistance (especially puncture-resistance), modulus, optics, oxygen barrier properties, etc.

Each layer of the film can be made from any suitable polymeric material, such as any suitable thermoplastic polymer or copolymer, such as polyolefin (e.g. ethylene/alpha-olefin copolymer), ethylene copolymer, polyamide, polyester, polyvinyl chloride, polypropylene, ethylene/propylene copolymer, homopolymers of ethylene, ethylene copolymers  
5 having at least 50 mole percent of an ethylene unit and a minor proportion of a monomer copolymerizable with ethylene, such as vinyl acetate, vinyl chloride, propylene, butene, hexene, acrylic acid and its esters, and methacrylic acid and its esters; polybutadiene. Examples of polyethylenic resins which can be advantageously employed include the invention are low-, medium- and high-density polyethylenes, and copolymers thereof.

10 Figures 2, 4, 5, and 6 depict a monolayer film. This monolayer film can comprise any suitable polymer, such as those listed above. Instead of a monolayer film, a multilayer film can be provided to make bags of the instant invention.

By way of example, Figure 3 shows a two layer film 88. Layer 89 is a layer that can be used as the bonding layer, to be joined to a like layer in a seamless tube, or to another  
15 layer of this or another film. The layers that make up the bonding layers of a bag of the invention can be the same or different either chemically or physically. Layer 90 is a second layer. Layers 88 and 89 can also contain appropriate amounts of other additives, such as slip agents such as talc, antioxidants, fillers, dyes, pigments and dyes, radiation stabilizers, antistatic agents, elastomers, and the like additives known to those of skill in the art of  
20 packaging films.

A multilayer film of the invention can have one or more internal or external film layers which have a primary function as an adhesive or compatibilizer (tie layer) for adhering two layers to one another; or provide abuse resistance, oxygen barrier, or other functionality. Usually, the core layer or layers provide the multilayer film with a desired level of  
25 strength, i.e., modulus, and/or optics, and/or added abuse resistance, and/or specific impermeability.

The multilayer films used in the present invention are optionally irradiated, before bag making and in some cases before orientation, to induce crosslinking. In the irradiation process, the film is subjected to an energetic radiation treatment, such as corona discharge, plasma, flame, ultraviolet, X-ray, gamma ray, beta ray, and high energy electron treatment, which induces cross-linking between molecules of the irradiated material. The  
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irradiation of polymeric films is disclosed in U.S. Pat. No. 4,064,296, to BORNSTEIN, et al., which is hereby incorporated in its entirety, by reference thereto. Radiation supplied to cure a radiation curable adhesive can also function to irradiate the film layers to induce crosslinking.

5     Thermoformed Container

Referring to Figures 10 to 13, container 250 has a first web 252 which is a forming web produced by thermoforming or other suitable techniques well known in the art. Suitable thermoforming methods, for example, include a vacuum forming or plug-assist vacuum forming method. In a vacuum forming method, the first web is heated e.g. by a contact heater and a vacuum is applied beneath the web causing the web to be pushed by atmospheric pressure down into a pre-formed mold. In a plug-assist vacuum forming method, after the first or forming web has been heated and sealed across a mold cavity, a plug shape similar to the mold shape impinges on the forming web and, upon the application of vacuum, the forming web transfers to the mold surface.

10    After the first web is in place, a product 254, such as a smoked sausage or other food or non-food product, is placed, such as by manual loading, on the first web. Either before, during, or after the step of placing the product 254 on the first web, a radiation curable adhesive is applied in either a continuous or discontinuous fashion in the peripheral area of the first web, on the surface of the first web that will be subsequently contacted by  
20    the peripheral area of a second web 256. The second, substantially non-forming web 256 is disposed over the product and the first web with the radiation curable adhesive disposed on the first web. A release of vacuum then causes the second web 256 to tack to the first web 252 so as to enclose the product between the webs and self-weld the first and second webs at their contiguous surfaces.

25    The radiation curable adhesive forms an intermediate layer 260 in the resulting package. The container is thereafter subjected to UV, electron beam, or other radiation sufficient to cure the adhesive and create a bond between the first web 252 and the second web 256. The radiation curable adhesive layer 260 thus becomes a bonding layer comprising a radiation cured adhesive.

30    Alternatively, the radiation curable adhesive can be applied in either a continuous or discontinuous fashion in the peripheral area of the second web (instead of the first web), on the surface of the second web that will be subsequently contacted by the periph-

eral area of the first web 252. In still another alternative, the radiation curable adhesive can be applied in either a continuous or discontinuous fashion in the peripheral area of both the first and second webs.

After the first and second webs 252 and 256 have been self-welded, and preferably before the shrinking operation described above is performed, the peripheral edge of the package is sealed or bonded by a radiation curable adhesive . This peripheral seal 260 is located at or near the actual periphery of the package.

Although the first and second webs 252 and 256 are depicted in Figure 13 as being of monolayer construction, like the films described herein, these webs can be of multi-layer construction, each layer comprising any suitable polymer such as those disclosed herein; of any suitable thickness; and made by any suitable process.

#### Film/Foam Composite

In FIG. 14, a film/foam composite 310 includes bottom film 311 and top foam sheet 312. Bottom film 311 comprises any suitable polymer such as those disclosed herein. Top foam sheet 312 comprises any suitable foam material, e.g. low density polyethylene foam having a density of about 2 pcf. In laminate 310, top foam sheet 312 and bottom film 311 are adhered together by means of a radiation curable adhesive layer 313. The polyethylene foam can be extruded in sheet form and then laminated to the polyethylene film.

One process of preparing the film/foam composite involves bringing together a moving continuous web of a thin sheet of polyethylene foam and a moving continuous web of the bottom film 311, as shown in Figure 15.. A radiation curable adhesive 323 is stored in a container 322, and applied from a nozzle 321 to one or both of the facing surfaces of the moving webs at the point of contact between the moving webs, to form radiation curable adhesive layer 313. The webs are then brought together by e.g. applying pressure by two opposing rollers 324 and 325 to the contacting webs at the point of contact of the moving webs. A radiation curing unit 326, e.g. a UV unit, is positioned downstream on one or both sides of the composite to achieve bonding of webs 311 and 312 together and transform radiation curable adhesive layer 313 to radiation cured adhesive layer 313. Although bottom film 311 is shown as a monolayer film, it can comprise two or more layers as disclosed herein.

The nip pressure applied by the opposed rollers on the laminate is typically between 0 to 10 pcf and about 150 pcf, e.g. about 60 pcf.

The moving continuous web of top foam sheet 312 can be formed by extrusion, passed through at least one oven, and, while being at a temperature between 350.degree.

- 5 F. and 500.degree. F., brought into contact with the moving continuous web of bottom film 311. The rollers can be chilling rollers.

The foam sheet can be that obtained from a third party or manufactured on site and later used, but in either case the foam sheet can be reheated just before it is laminated with the polyethylene film. The lamination can be done using extruded foam

10 sheet at an elevated temperature immediately after exiting the oven(s) downstream from the extruder.

Typically, polyethylene films are 10 mils thick or less, and polyethylene sheets are greater than 10 mils thick.

- 15 The foam sheet 312 can be formed by means of a conventional polyethylene foam sheet extrusion process or any other suitable foam sheet-forming process. The foam sheet can be open or closed celled.

The bottom film 311 can be formed by means of a conventional film extrusion process or any other suitable film-forming process.

- 20 If the bottom film 311 comprises a heat shrinkable material, made by orientation techniques well known in the art, and if the radiation curable adhesive is applied at specific intermittent points along the interface between the bottom film 311 and top foam sheet 312, then upon the application of sufficient heat, the composite will deform to an undulating structure.

#### Inflatable Packaging Cushion

- 25 Referring to FIGS. 16, 17 and 18, these show a first embodiment of an inflatable packaging cushion 100 of the invention, intended to wedge and to protect one or more objects to be packaged.

- 30 This inflatable cushion 100 includes an external peripheral edge 101 which here describes essentially a rectangle and which is generally adapted to the shape and to the dimension of a packaging receptacle, for example a box made from rigid cardboard; a trayed package including a tray, a product disposed in the tray, and a lidstock sealed to the top of the tray; or the like. This inflatable cushion 100 includes an internal opening 102,

which is rectangular for example, capable of receiving at least one object 500 to be packaged and a plurality of recesses 103, here four recesses 103 extending from each of the corners of the rectangular internal opening 102 towards the peripheral edge 101 of the said cushion 100 and more precisely in the direction of the corners of the said peripheral edge 101. As shown in FIGS. 16, 17 and 18, the inflatable cushion 100 includes two sheets of flexible plastic (of any suitable polymer or blend of polymers as disclosed herein), juxtaposed and bonded together in the region of their edges along the bonding lines LS.

As seen in FIGS. 17 and 18, the recesses 103 delimit, in pairs, wedging parts 104, 105, 106, 107, here four wedging parts capable of coming into contact with the object 500 to be packaged, by pivoting around preferential pivoting zones 108 defined between the recesses 103 and the peripheral edge 101.

The pivoting of the wedging parts 104, 105, 106, 107 around the preferential pivoting zones 108 enables the size and/or the shape of the internal opening 102 to be varied in order to adapt it to objects of various sizes and/or shapes, whilst exerting a holding pressure on the object or objects to be packaged by virtue of a return movement which is exerted in the region of the pivoting zones 108. In this case, the shape of each recess 103 and/or of the peripheral edge 101 is such that, in this region, two preferential pivoting zones 108 are located respectively at two locations where the space between the recess 103 and the external peripheral edge 101 of the cushion 100 is the least. In this example, the peripheral edge 101 is substantially straight between two corners and each recess 103 is substantially droplet shaped, that is to say has a shape constituted by two lines 103b, 103c diverging from a corner of the internal opening 102 towards the peripheral edge 101 and joined together by a rounded portion 103a in the vicinity of this edge. In the region of the rounded portion 103a, there are two locations where the space between the recess 103 and the external peripheral edge 101 is the least and these two locations define two preferential pivoting zones 108. The shapes of the recesses 103 and/or of the peripheral edge 101 which are described are not unique and the person skilled in the art will be able to make modifications to them, knowing that it suffices to create, between one recess 103 and the peripheral edge 101, at least one narrowing so as to define at least one preferential pivoting zone 108.

The external peripheral edge 101 can have indentations in the region of each recess 103 in order to define, with the recess, the preferential pivoting zones 108. As may be better seen in FIG. 18, the shape and the dimension of the recesses 103 and of the peripheral edge 101 are such that, during the inflating, two neighboring wedging parts 5 spontaneously pivot in opposite directions, this spontaneous pivoting being due in particular to the fact that the inflating of the cushion will generate certain tensions in its material, especially in the neighboring region of the recesses, and that these tensions are at a minimum after such a pivoting has occurred.

The four lateral intersecting edges of the object 500 placed in the inflatable cushion 100 are engaged in the recesses 103; they are not in contact with the cushion, which minimizes the risk of wear or of deterioration of the cushion by these intersecting edges. The recesses constitute, by virtue of their deformability, preferential impact-damping zones.

The inflatable cushion 100 shown in FIGS. 16, 17 and 18 has a self-sealing inflating valve 109 located on one side of the peripheral edge 101, enabling the cushion to be inflated or deflated by means of an inflating hose which is inserted into the valve. This inflating valve 109 can be placed equally on any edge of the cushion 100 and, for example, on the edge of the internal opening 102, emerging naturally towards the interior of the opening. FIG. 19 shows an alternative embodiment of the inflatable cushion 100 of FIG. 16, which here includes two internal openings 102, 102' of square shape. It comprises 15 eight recesses 103, 103' which extend from each of the corners of each square internal opening 102, 102' towards the peripheral edge 101 of the cushion 100. The cushion includes four flats beveled at the four corners. The internal openings 102, 102' are placed such that each opening 102, 102' comprises two recesses 103, 103' extending in the direction respectively of two corners of the peripheral edge 101 and two recesses 103, 103' 20 extending respectively towards the centers of the longitudinal parts 101a, 101b of the peripheral edge 101. The cushion 100 shown in FIG. 19 then comprises eight pivoting wedging parts 104, 105, 106, 107, 104', 105', 106', 107' each defined by two successive recesses, the wedging parts being capable of coming into contact with one or more objects 25 to be packaged. Moreover, as may be seen in FIG. 19, the cushion 100 comprises a fixed central wedging part 110 which extends between the openings 102, 102' and which includes a central hole 117, produced by cutting the two sheets forming the cushion and 30

bonding the cut edges of the sheets along the line LS. This circularly-shaped central hole makes it possible to act as an impact-absorbing buffer when the cushion is placed between the face of a packing box and an object to be packaged. In addition, this circular hole 117 enables the thickness of the cushion in the inflated state to be limited.

5 FIG. 20 shows another alternative embodiment of the inflatable cushion 100 of FIG. 16, which includes two internal openings 102, 102' each having an essentially straight shape. The internal openings 102, 102' arranged in parallel have a recess 103, 103' at each end. The cushion 100 then includes four recesses 103, 103', each of the recesses extending in the direction of a corner of the peripheral edge 101. The cushion 100  
10 comprises three wedging parts 104, 104', 105. Two of the wedging parts 104, 104' can pivot and each is delimited by the two recesses 103, 103' extending from the openings. The third wedging part is a fixed central part 105 lying between the two openings 102, 102'. The cushion 100 includes at the center of the central wedging part 105, two circular  
15 holes 117 which make it possible to limit the thickness of the inflated cushion and to act as an impact absorber. In the same manner as for the cushion of FIG. 19, the four corners of this cushion have a beveled flat area.

FIG. 21 shows another inflatable cushion 200. Cushion 200 is designed to be inserted into a packaging item such as a box having articulated closure flaps adjacent, by one of their edges, to a corner of the box, as well as an inflatable cushion 100 of the type  
20 shown in FIGS. 16, 17, 18, 19 and 20.

In FIG. 21, the inflatable cushion 200 comprises two sheets 220 of flexible plastic, bonded together in the region of their edges along the bonding line LS. As may be seen in FIG. 21, the inflatable cushion 200 has a rectangular shape adapting to the shape and to the dimension of a box. This cushion shape is suitable for packing receptacles having essentially parallelepipedal shapes. The inflatable cushion 200 can include a self-sealing inflating valve 210 located in a corner region of the cushion 200. When the latter is installed in a box, the inflating valve 210 is placed in the region of a corner of the box, which enables the cushion 200 to be inflated from outside, after closing the articulated flaps, by means of an inflating hose 400 inserted into the valve 210. This inflating characteristic enables a packing box having flaps to be used without any particular arrangement for allowing the hose to pass.  
25  
30

As may be seen in FIGS. 21, 22 and 23, the self-sealing inflating valve 210 comprises two thin sheets 211 of plastic juxtaposed and bonded together along two parallel lines so as to form a passage conduit for the inflating hose 400, open at both ends. As may be better seen in FIG. 22, the inflating valve 210 is located between the two sheets 220 forming the cushion 200 in the corner region of the cushion. Furthermore, the valve, as FIG. 21 shows, extends from a corner of the cushion only along a part of the length of one diagonal of the cushion, which enables the cushion to be deflated by inserting the hose 400 into the valve beyond the free end of the passage conduit.

According to a variant of the self-sealing inflating valve 210 shown in FIG. 23, the parallel bonding lines of the two thin sheets 211 move apart locally such that the passage conduit for the inflating hose created by the lines includes a widening located some distance from the free end of the conduit placed inside the cushion 200.

Thus, when the inflating of the cushion 200 is stopped and when the hose 400 is still partially engaged in the passage conduit, the two thin sheets 211 are applied mutually against each other by virtue of a distortion caused in the vicinity of the free end of the conduit by the widening, so as immediately to obstruct the conduit and thus prevent the cushion from partially deflating. In addition, as FIGS. 21, 23, 24 and 25 show, the sheets 211 are bonded together at one of their ends and at the two sheets 220 forming the cushion along a bonding line 212a extending along a beveled flat 212 of the corner of the cushion, thereby leaving a non-bonded zone in line with an adjacent opening 215 of the conduit in order to allow the conduit to be open to the outside for inserting the inflating hose 400.

In order to facilitate the insertion of the hose into the conduit, there is provision, as may be seen in FIGS. 21, 23, 24 and 25, for the inflatable cushion to include two flexible guide tabs 213, each of which is constituted by the prolongation, in superposition, of a sheet 220 of the cushion and of a sheet 211 of the valve. As shown in FIGS. 23 and 24, a peripheral bond 212b, separate from the bonding line 212a along the beveled flat 212, firmly attaches these sheets together and has edges located in the prolongation of the adjacent edges of the cushion 200. As may be seen in FIGS. 23, 24 and 25, the end of the inflating valve is bonded to the cushion along a bonding line 212a, this bond linking, on the one hand, the two thin sheets 211 and the two sheets 220 constituting the cushion. Alternatively, as shown in FIG. 25, a single bonding line 212a' can be seen, which extends along the beveled flat 212 and which makes it possible, on the one hand, to bond together

the sheets forming the self-sealing valve and to bond them to the sheets forming the cushion, and, on the other hand, to firmly attach the sheets constituting the guiding tabs to the cushion. It will be noted that the bonding line 212a' has a width markedly greater than that of the single bonding line 212a. This allows the possible inscription, within the bonding line 212a', of a mark or of any specification relating to the cushion.

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The inflatable cushions 100 shown in FIGS. 16, 17, 18, 19 and 20, can themselves also include, if necessary, a self-sealing inflating valve in a corner, according to the embodiments shown more particularly in FIGS. 7, 23, 24 and 25.

In each instance in the above disclosure, where a bond is disclosed, this bond can  
10 be made using a radiation curable adhesive (or a blend of radiation curable adhesives) which can be applied by any suitable means, such as coating, printing, etc., manually or by machine, in a continuous or discontinuous fashion, randomly or in a predetermined pattern, geometry, or profile, to one or both of the relevant surfaces that are to be adhered together.

15 **Radiation Curable Adhesives**

Radiation curable adhesives useful in place of heat seals can be selected based on cationic, free radical, and hybrid chemistries. Radiation curable adhesives offer much faster production speeds than conventional heat seal processes. They can be used to construct a variety of adhesive junctions that can replace heat seals. Because radiation  
20 curable adhesives can be applied via traditional coating processes, the options for specific shapes or geometries are vast and allow patterns not possible with heat seals, in a fast, continuous, laminating and curing process.

Radiation curable adhesives offer the advantage of bonding films with controllable bond strengths that can be moderate such as for tacking or tamper evident applications to  
25 very high with substrate destruction before bond failure. Bond strengths also can be controlled through formulation and dose from low to high bond strength.

Radiation curable pressure sensitive adhesives are available with controlled tack and bond strength that allow easy removable, reclosable or permanent bonds along with improved properties such elevated temperature resistance not possible with thermoplastic  
30 type adhesives.

The radiation curable adhesive can be applied by flexographic, rotogravure, rotoscreen, ink jet, roll coating and other dispensing methods.

This approach offers several advantages over the currently used heat sealing process that includes allowing complex patterns to be printed on wide web in any desired cushion pattern. The printing process can allow high throughput of about 200 fpm.

- The adhesive beneficially can rapidly form strong bonds to the film, web, or other substrate on which it is applied. It is desirable that the radiation curable adhesive have the following characteristics as shown in Table 1.
- 5

Table 1

<u>Desirable Adhesive Characteristic</u>	<u>Radiation Curable Adhesives</u>
No/low volatile organic compounds (VOC's), (no solvents), Application/printing flexibility	Typically no VOC's used. Diluents if used, crosslink into polymer network Has capability to be applied by various printing processes such as flexo, gravure, roto-screen, ink jet and other dispensing methods. UV adhesives can be immediately laminated and UV light cured as continuous operation. UV curing process can often be carried out at 500 to 800fpm.
Printed adhesive pattern can be immediately laminated and cured in-line as a rapid continuous in-line processes.	Much lower space requirements compared to drying tunnels. UV light irradiators are available that are less than 12 inches wide. Power supplies also have low space requirements. Cationic systems reach full cured properties in hours. Fully cured properties reached in seconds with radical type system
The curing equipment has a low foot print and can be retrofitted to existing lamination lines.	Typically 1 part thermoset type system and storage stable, even when left on application equipment.
Rapid development of full cured properties.	Temperature sensitive substrates can be used with commercially available systems. Low temperature curing with proper engineering controls.
Handling and storage ease.	
Not distort film	

- 10        The surface of the film, web, or other substrate on which the radiation curable adhesive is applied can be corona pre-treated by standard corona treatment techniques.

A low adhesive viscosity is beneficial for room temperature application if a flexographic printing method is employed, but application of a radiation curable adhesive at elevated temperatures is also possible.

- 15        In some cases, matching of the radiation curable adhesive formulation to the film, web, or other substrate on which the radiation curable adhesive is to be applied can be beneficial.

Film substrates must be at least partially UV light transparent for free radical type chemistries, where UV light is used as the radiation type, since the adhesive is cured through the film, although there are commercial processes based on UV cationic type chemistry where the adhesive is initiated just before the film is laminated.

- 5 For example, the adhesive systems are formed or derived from radiation-curable (i.e., radiation-polymerizable) components. Such systems have the ability to change from a fluid phase to a highly cross-linked or polymerized solid phase by means of a chemical reaction initiated by a radiation energy source, such as ultra-violet ("UV") light or electron beam ("EB") or other ionizing radiation. Thus, the reactants of the radiation-curable adhesive systems are "cured" by forming new chemical bonds under the influence of radiation.
- 10

Radiation-curable adhesive systems or formulations that are cured by a free radical mechanism typically include: i) monomers (e.g., low-viscosity monomers or reactive "diluents") capable of polymerization by free radical mechanism, ii) oligomers/prepolymers (e.g., acrylates) capable of polymerization by free radical mechanism, and optionally iii) other additives, such as non-reactive plasticizing diluents. Radiation-curable adhesive systems that are cured by UV light also include one or more photoinitiators. Radiation-curable radical adhesive systems curable by electron beam (EB) radiation do not require a photoinitiator, and may therefore be free of photoinitiator. Together, these monomers and oligomers/prepolymers may be grouped as "reactants."

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Reactive (meth)acrylate diluents include, but are not limited to, trimethylolpropane triacrylate, hexanediol diacrylate, 1,3-butylene glycol diacrylate, diethylene glycol diacrylate, 1,6-hexanediol diacrylate, neopentyl glycol diacrylate, polyethylene glycol 200 diacrylate, tetraethylene glycol diacrylate, triethylene glycol diacrylate, pentaerythritol tetraacrylate, tripropylene glycol diacrylate, ethoxylated bisphenol-A diacrylate, propylene glycol mono/dimethacrylate, trimethylolpropane diacrylate, di-trimethylolpropane tetraacrylate, triacrylate of tris(hydroxyethyl) isocyanurate, dipentaerythritol hydroxypentaacrylate, pentaerythritol triacrylate, ethoxylated trimethylolpropane triacrylate, triethylene glycol dimethacrylate, ethylene glycol dimethacrylate, tetraethylene glycol dimethacrylate, polyethylene glycol-200 dimethacrylate, 1,6-hexanediol dimethacrylate, neopentyl glycol dimethacrylate, polyethylene glycol-600 dimethacrylate, 1,3-butylene glycol dimethacrylate, ethoxylated bisphenol-A dimethacrylate, trimethylolpropane trimethacrylate, diethylene

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glycol dimethacrylate, 1,4-butanediol diacrylate, diethylene glycol dimethacrylate, pentaerythritol tetramethacrylate, glycerin dimethacrylate, trimethylolpropane dimethacrylate, pentaerythritol trimethacrylate, pentaerythritol dimethacrylate, pentaerythritol diacrylate, aminoplast (meth)acrylates, and acrylated oils such as linseed, soya, and castor oils.

- 5 Other polymerizable compounds that can be used include (meth)acrylamides, maleimides, vinyl acetate, vinyl caprolactam, polythiols, vinyl ethers and the like. Monoacrylates such as cyclohexyl acrylate, isobornyl acrylate, lauryl acrylate and tetrahydrofurfuryl acrylate and the corresponding methacrylates are also operable as reactive diluents as well as (meth)acrylate oligomers such as epoxy acrylates, urethane acrylates, and polyester or 10 polyether acrylates.

Useful oligomers/prepolymers include resins having acrylate functionality, such as epoxy acrylates, polyurethane acrylates, and polyester acrylates. Exemplary oligomers and prepolymers include (meth)acrylated epoxies, (meth)acrylated polyesters, (meth)acrylated urethanes/polyurethanes, (meth)acrylated polyethers, (meth)acrylated 15 polybutadiene, aromatic acid (meth)acrylates, and (meth)acrylated acrylic oligomers and the like.

- If the radiation-curable adhesive are cured by free radical mechanism and formulated for curing by exposure to UV-light, then the adhesive includes one or more photoinitiators. Photoinitiators for free radical curing are well known to those skilled in the art.
- 20 Specific examples include, but are not limited to, the benzoin alkyl ethers, such as benzoin methyl ether, benzoin ethyl ether, benzoin isopropyl ether and benzoin isobutyl ether. Another class of photoinitiators are the dialkoxyacetophenones exemplified by 2,2-dimethoxy-2-phenylacetophenone, i.e., IRGACURE®651 (Ciba-Geigy) and 2,2-diethoxy-2-phenylacetophenone. Still another class of photoinitiators are the aldehyde and ketone 25 carbonyl compounds having at least one aromatic nucleus attached directly to the carboxyl group. These photoinitiators include, but are not limited to benzophenone, acetophenone, o-methoxybenzophenone, acetonaphthalequinone, methyl ethyl ketone, valerophenone, hexanophenone, alpha-phenyl-butyrophenone, p-morpholinopropiophenone, dibenzosuberone, 4-morpholinobenzophenone, 4'-morpholinodeoxybenzoin, p- 30 diacetylbenzene, 4-aminobenzophenone, 4'-methoxyacetophenone, benzaldehyde, alpha-tetralone, 9-acetylphenanthrene, 2-acetylphenanthrene, 10-thioxanthene, 3-acetylphenanthrene, 3-acetylindone, 9-fluorenone, 1-indanone, 1,3,5-triacetylbenzene,

thioxanthen-9-one, xanthene-9-one, 7-H-benz[de]-anthracen-7-one, 1-naphthaldehyde, 4,4'-bis(dimethylamino)-benzophenone, fluorene-9-one, 1'-acetonaphthone, 2'-acetonaphthone, 2,3-butedione, acetonaphthene, benz[a]anthracene 7,12 diene, etc.

5 Phosphines such as triphenylphosphine and tri-o-tolylphosphine are also operable herein as photoinitiators. The photoinitiators or mixtures thereof are usually added in an amount ranging from 0.01 to 5% by weight of the total composition.

Radiation-curable adhesive systems or formulations that are UV cured by cationic mechanism typically include: i) monomers, oligomers and/or polymers that are capable of cationic polymerization such as but not limited to aliphatic and/or cycloaliphatic epoxides and/or vinyl ethers, many of which are known to one skilled in the art , ii) one or more cationic photoinitiators that are known to one skilled in the art as onium salts, and optionally iii) polyols (organic compounds that contain hydroxyl functionality that are capable of adding to protonated epoxide) and other additives, such as non-reactive plasticizing diluents. There are many epoxides and vinyl ethers that are suitable. but cycloaliphatic epoxides (containing at least one epoxide group) are preferred. Examples include but are not limited to epoxides sold under the CYRACURE® (Dow Chemical) or UVACURE™ (UCB Chemical) trade names. The cycloaliphatic epoxides with cationic photoinitiator(s) may be used alone or in combination with polyols at varying concentrations. Examples of polyols include polycaprolactone type polyols but other polyols may be used.

20 UV cationic onium type photoinitiators useful for UV curable cationic adhesives are well known by one skilled in the art. US Patent Nos. 4407759 and 4417061, both incorporated herein by reference in their entirety, are useful for describing onium type photoinitiators of which there are many types commercially available. Examples of commercially available onium type photoinitiators include but are not limited to SarCAT® CD-1012 and

25 KI-85™ from Sartomer.

Another type of UV adhesive that has found utility are, but are not limited to, mixtures of free radical UV adhesives and cationic UV adhesives. They are sometimes called hybrid systems because they have components that have been previously described as useful in free radical UV adhesives, and components that have been previously described as useful in cationic UV adhesives. These hybrid adhesives cure by free radical and cationic mechanisms when exposed to light useful for inducing polymerization. Some onium salt cationic photoinitiators such as iodonium compounds can be optionally used in

combination with free radical type photoinitiators such as 2- isopropyl thioxanthone to improve the UV light cationic initiation. An example of this type of mixed UV cationic photoinitiator system include but not limited to UV 9380 (GE Silicones).

Although the radiation cured adhesive layer of the various embodiments is typically shown as extending the full width or length of a given article, alternatively the radiation curable adhesive can be applied along a selected region of the article, in a continuous or discontinuous manner or pattern as desired, in either the longitudinal direction or with respect to the article width.

Other radiation curable adhesives that cure by a free radical mechanism can be used in connection with the present invention, of which an example is listed in Table 3, but are not preferred.

Table 3

Material Name	Supplier	Material type/function	parts
TMP-TA™	UCB Chemicals Corp	free radical crosslinker	46.4
RICON™ 3801	Sartomer	acrylated polybutadiene crosslinker	46.2
ODAB™	First Chemical Corp.	Liquid amine synergist	1.8
IRGACURE® 819	Ciba	Phosphine oxide type free-radical photoinitiator	0.4
LTX™	First Chemical Corp.	liquid thioxanthone type free-radical photoinitiator	0.92
BD-1™	First Chemical Corp.	Blend of free-radical photoinitiator	2.78

The ratios and amounts of the components used in E and F can be varied by one skilled in the art.

Other cationic photoinitiators can be used as the "E" UV adhesive(e.g. CD1012).

Other free radical photoinitiators can be used as the "F" adhesive.

The adhesives can be storage stable when properly stored.

The adhesives can have viscosities that allow rapid and easy application at room temperature.

An electron beam (EB) is one useful form of radiation, although UV-light radiation can also be used. The radiation source for an EB system is known as an EB generator.

Two factors are important in considering the application of EB radiation: the dose delivered and the beam penetration. The dose is measured in terms of quantity of energy  
5 absorbed per unit mass of irradiated material; units of measure in general use are the megarad (Mrad) and kiloGray (kGy). The depth of penetration by an electron beam is directly proportional to the energy of the accelerated electrons impinging on the exposed material (expressed as kiloelectron volts, keV).

Regardless of the radiation source, the radiation dose will be sufficient and effective  
10 to cure the radiation curable adhesive.

Useful radiation dosages can range from e.g. 0.2 to 10 Mrads. Useful energies for the EB can range from 30 to 250 keV.

Useful EB generation units include those commercially available from American International Technologies sold under the trademark MINI-EB™ (these units have tube operating voltages from about 30 to 70 keV) and from Energy Sciences, Inc. sold under the trademark EZ CURE™ (these units have operating voltages from about 70 to about 110 keV). EB generation units typically require adequate shielding, vacuum, and inert gassing, as is known in the art. If the processing techniques employed allow for the use of a low oxygen environment, the coating and irradiation steps beneficially occur in such an atmosphere. A standard nitrogen flush can be used to achieve such an atmosphere.  
20

#### Radiation Curable Adhesive Thickness

The radiation curable adhesive is applied in a thickness that once cured is effective to provide the desired bond strength. Useful average thicknesses of radiation curable adhesive include, without limitation, from 0.1 to 12 micrometers. An adhesive thickness of  
25 more than 12 micrometers, at least in parts of the bond in certain applications, such as the bond around a self sealing valve (see FIG 20 to 25) may be beneficial depending on the total thickness of the valve. In the case of an intermittent, discontinuous adhesive layer, the average thickness of 0.1 to 12 micrometers is directed to the regions or portions that actually contain the adhesive. Other average thicknesses that may be useful  
30 depending upon the particular application include from 0.5 to 10 micrometers, such as 1 to 8, 2 to 7 and 3 to 6 micrometers.

The radiation cured adhesive, once it forms a bonding layer or region within an

article, should be able to withstand normal packing, distribution, and handling.

The radiation curable adhesive can be used as a bonding medium for many different package formats that traditionally rely on heat sealing or other sealing mechanisms. Examples include VFFS packages, HFFS packages, lidded trays or cups, pouches, bags, or other like packages.

Useful package configurations for use in connection with the present invention include end-seal bag, a side-seal bag, an L-seal bag (e.g., sealed across the bottom and along one side with an open top), or a pouch (e.g., sealed on three sides with an open top). Such bag configurations are known to those of skill in the art. See, for example,

- 10 U.S. Patent 5,846,620 issued December 8, 1998 to Compton, which is incorporated herein in its entirety by reference. Additionally, lap seals may be employed, in which the inside region of the film is bonded to an outside region of the film. In each of these formats and those disclosed herein, any or all of the seals traditionally formed by heat or alternative sealing technologies can be replaced by a radiation cured adhesive bond. Those skilled in  
15 the art will also appreciate that the present invention can be used in conjunction with traditional heat sealing or other sealing methods. Thus, e.g. a bag, thermoformed container, film/foam composite; or inflatable packaging cushion, could have one or more radiation cured adhesive bonds, as well as one or more heat seals.

Suitable food products for packaging by the present method include fatty foods  
20 (e.g., meat products, cheese products), aqueous foods (e.g., produce and some soups), and dry food (e.g., cereal, pasta). Examples of meat products that may be packaged include, poultry (e.g., turkey or chicken breast), bologna, braunschweiger, beef, pork, lamb, fish, and whole muscle products such as roast beef, and other red meat products. Examples of produce or vegetables that may be packaged include cut and uncut lettuce,  
25 carrots, radish, and celery. The food product may be solid, solid particles, dry, fluid, or a combination thereof.

A film can also be wrapped around a product and bonded together as described herein to form a package enclosing the product. If the film is a heat-shrinkable film, the resulting bag or other container can be heated to shrink the film around the product.

30 The above descriptions are those of various embodiments and examples of the invention. Various alterations and changes can be made without departing from the spirit and broader aspects of the invention as defined in the claims.

Any reference to an item in the disclosure or to an element in the claim in the singular using the articles "a," "an," "the," or "said" is not to be construed as limiting the item or element to the singular unless expressly so stated.

- Any numerical values recited herein include all values from the lower value to the  
5 upper value in increments of one unit provided that there is a separation of at least 2 units between any lower value and any higher value. As an example, if it is stated that the amount of a component, or a value of a process variable and the like is, for example, from 1 to 90, such as 20 to 80, such as 30 to 70, it is intended that values such as 15 to 85, 22 to 68, 43 to 51, 30 to 32 and the like, are expressly enumerated in this specification.  
10 For values which are less than one, one unit is considered to be 0.0001, 0.001, 0.01 or 0.1 as appropriate. These are only examples of what is specifically intended and all possible combinations of numerical values between the lowest value and the highest value enumerated are to be considered to be expressly stated in this application in a similar manner.

15